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ASSESSMENT OF FARMERS' VULNERABILITY AND ADAPTATION, TO THE IMPACT OF CLIMATE CHANGE IN CHITWAN AND PARBAT DISTRICTS OF NEPAL

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ABSTRACT

The research was conducted in order to assess the farmers' vulnerability, impact of climate change and adaptation towards it in Chitwan district of terai and Parbat district of mid-hill region of Nepal. Two VDCs from each district and 30 households from each VDCs, altogether 120 households were randomly selected for the study. Primary data was collected during field survey through pre-tested interview schedule (questionnaire), Focus Group Discussions (FGDs) and Key Informants Interview (KII). Vulnerability index using integrated vulnerability approach based on the principal component analysis, logistic regression model, and scaling index were estimated to assess the result. Adoption rate of adaptation strategies was higher in Chitwan (73.33 percent) in comparison with Parbat (48.33 percent). Different adaptation strategies practiced by the farmers in the study area are change in crop varieties (80 percent), increasing irrigation/ water management (69.29 percent), application of organic manures and bio-fertilizers (66.70 percent), remittance and outside employment (61.70 percent), change in sowing and harvesting time (45.80 percent), moisture conservation and soil management practices (42.50 percent), change in cropping pattern or crop diversification (35.50 percent), IPM practices (32.35 percent), off-season vegetable cultivation (26.00 percent) and rain water harvesting (5.90 percent). Lack of information and knowledge concerning appropriate adaptation measures, low access to water, lack of technology, and poverty were seen as major barriers to the adaptation. Parbat (mid-hill) was more vulnerable to climate change by its least index (5.7) in comparison to Chitwan (terai) having high index (8.3). Social background or caste of the household, years of schooling of the household head, total cultivated landholdings of the household, saving of the household, training and extension services received and member of organization showed positive and significant impact on the farmers' decision of adopting different adaptation strategies. Policies should support to raise awareness towards climate change and adaptation strategies, disseminate the effective training programs and extension services, intensive research activities, provision of credit, and allocation of sufficient budget on climate change issues and agriculture sector.

KEYWORDS: *Climate Change, Vulnerability & Adaptation Etc*

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INTRODUCTION

Agriculture is the major sector of Nepalese economy. It provides employment opportunities to 66 percent of the total population and contributes about 35 percent in the GDP (MoAD, 2013).

Climate change refers to a persistent change in the mean and variability of climatic parameters

(temperature, rainfall, humidity and soil moisture) due to change in composition of atmospheric gases (IPCC *et al.*, 2007). The change in atmospheric composition is attributed to the anthropogenic emissions of green house gases such as carbon-dioxide (Co_2), methane (NH_4), and other gases. The concentration of green house gases in the atmosphere has increased significantly since the industrial revolution in 1970's. The amount of Carbon dioxide (Co_2) has increased by 31 percent, methane by 151 percent and nitrous oxide by 17 percent (Regmi, 2007).

Nepal's share in climate change is negligibly small. The population of Nepal is less than 0.4 percent of the world population and is responsible for only about 0.025 percent of annual greenhouse gas emissions (NAPA/MOE, 2010). However, Nepal is in vulnerable position with regard to climate change due to fragile ecosystem, which is very sensitive to even slight changes in natural climate, weaker geological situation and complex topography. The rise of temperature is greater in Nepal than the average of global rise with intense rainfall, floods and droughts. Gradually, year-by-year changes in temperature have also been observed, with a 0.09 ºC per year increase, recorded in the Himalayas and 0.04 ºC per year increase in Terai with higher increase in winter (Practical Action Nepal, 2008).

Climate change is expected to influence crop and livestock production, hydrological balances, input supplies and other components of agricultural systems (Moench*et al.*, 2003). FAO (2006) reports that, climate change will affect all four dimensions of food security, namely, food availability, access to food, stability of food supplies and food utilization. If agricultural production in Nepal is adversely affected by the climate change, the livelihood of two-third of the labor force, particularly of the rural people will be at risk. APP (1995) had revealed long ago that Nepal which was once a food exporting country has become a net importer due to declining food production. Decline in food production will lead to more malnutrition and huge consequences particularly for children (Human Development Report, 2007). Climate change has serious impact on major food crops and livelihood of farming community. Unequal land distribution, traditional farming system and micro-climatic adversities perpetuated by the climate change brings additional challenges of food security in Nepal (Practical Action, 2007/2008, Annual Report). Thus, climate change is likely to have serious consequences for sustainability of Nepalese agriculture along with adverse impacts on other aspects like health, food security, environment, natural resources and physical resources.

Chapagain *et al.* (2007) indicated that, climate change is likely to have serious consequences for Nepal's agriculture. The poor farming communities will be the most vulnerable to the predicted impacts of climate change. The subsistence and poor farming communities tend to always reliant on rain fed agriculture and occupy the marginal land, which is most at risk from every aspect. Even small change in rainfall pattern and temperature can have devastating consequences throughout the growing period.

METHODOLOGY

Study Area, Data Size and Data Collection Technique

The study was conducted in Chitwan and Parbat districts of Nepal, comprising both Terai and Mid-hills. Padampur and Saradanagar VDCs of Chitwan; Devisthan and Khanigaun VDCs of Parbat was selected purposively, as livelihood of most of the people depends on agriculture and livestock sector in these areas. Altogether 120 households, 30 households from each four VDCs were selected using Random Sampling Technique. Field survey was conducted to collect both quantitative and qualitative data by means of structured and semi-structured questionnaire, focus group discussions (FGD), direct observations and key informant interview. Secondary information was collected from CBS, DADO and MOAD of the study area. Data about precipitation pattern, temperature, etc. was collected from the Department of

Hydrology and Meteorology.

Logistic Regression Model

Logistic regression model model will be used, to assess the factors affecting the farmer's decision on adopting the adaptation strategies against climate change by the farmers. The binary logistic model will be applied to analyze the determinants of farmers' decision on adopting adaptation measures ($Y_i = 1$) in the study area. The logistic model will be used to analyze the binary or dichotomous response and allows examining how a change in any independent variable changes all the outcome probabilities (Regmi, 2010).

The binary logistic regression model can be operationalized as:

$$Logit \quad P(Y_i^*) = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_i$$

$$\text{Logit (Adopt = 1)} = \gamma\,'\,\mathrm{K} + \varepsilon_i$$

The regression model is expressed as:

Y_i (Adopt=1) = $\alpha_0 + \alpha_1.X_1 + \alpha_2.X_2 + \alpha_3 X_3 + \alpha_4.X_4 + \alpha_5.X_5 + \ldots\ldots\ldots\ldots\ldots\ldots + e_i$

Where,

$\alpha_{0=}$ a constant term

$X_1, X_2, X_3, X_4, \ldots\ldots\ldots$ are independent variables such as:

Age of household head, Sex of household head, Social background of hh (dummy), Years of schooling, Primary occupation (dummy), Total land holding (ha.), Saving (dummy), Membership in Organization (dummy), Access to credit (dummy), No. of economically active population, Training and extension service received (dummy), Farmers' experience, Information/ Level of knowledge on Climate change (dummy), etc.

Vulnerability Assessment

The study uses the integrated assessment approach using indicators to analyze vulnerability, which is the most common method. Also, it is used to develop the understanding of the contribution of socio-economic and biophysical factors to vulnerability (Hebb and Mortsch, 2007). The indicators were undertaken, based on the review of literature. The indicators were based on Exposure, Sensitivity and Adaptive Capacity. The data on adaptive capacity and sensitivity were obtained from primary and secondary sources. Principal Component Analysis (PCA) was performed to compute the component score to weigh the variables to calculate the vulnerability indices. According to Filmer and Pritchet (2001), the first principal component defines the linear index of all the variables from a set of variables which capture the largest amount of information common to all the variables.

Vulnerability was calculated as defined by IPCC (2001),

Vulnerability = (adaptive capacity) - (sensitivity + exposure) 1.1

Equation 1.1 can be operationalized as follows:

$$V_k = \sum_{i=1}^{n} W_{ki}.X_{ki} - \left(\sum_{i=1}^{n} W_{ki}Y_{ki} + \sum_{i=1}^{n} W_{ki}Z_{ki} \right) \tag{1.2}$$

Where,

i = 1, 2, 3, … n Households

k=1, 2 for Chitwan and Parbat, respectively.

V_k =Vulnerability index for k^{th} district.

W_{ki}=Weight from first principal component scores of i^{th} variable for k^{th} district.

X_{ki}= Adaptive i^{th} for k^{th} district.

Y_{ki} =Sensitivity i^{th} for k^{th} district.

Z_{ki}= Exposure i^{th} for k^{th} district.

Higher the net value or indices, lesser the vulnerability and vice versa (Madu, 2012).

Scaling Index

The level of knowledge/ information of the respondents about the climate change, and the problems/ constraints on adopting the adaptation strategies by the farmers will be analyzed by using the scaling index. The ranking was done by calculating index value. Following formula will be used to find out the index value.

Index value= $\sum S_i f_i / N$

Where,

I= Priority index

∑= Summation

S_i= Scale value at i^{th} priority

F_i= Frequency of i^{th} priority

RESULTS AND DISCUSSIONS

Vulnerability Assessment

Vulnerability is the function of adaptive capacity, sensitivity and exposure. To analyze the vulnerability of farmers of Chitwan and Parbat districts, the weight or score for different indicators was generated by principal component analysis, which was calculated separately for adaptive capacity, sensitivity and exposure. But the weight for sensitivity is taken as coefficient obtained from the trend analysis of average annual maximum temperature, average annual minimum temperature and average annual rainfall variability over last 30 years. The principal component score analyzed through principal component analysis is shown in Table 1. According to Filmer *et al.* (2001), the first principal component defines the linear index of all the variables from a set of variables which captures the largest amount of information common to all variables.

Table 1: Principal Component Score of Chitwan and Parbat Districts

Indicators	Chitwan	Parbat
Adaptive capacity		
Upper caste	0.343	0.452
Education status of household head	0.541	0.368
Number of educated economically active members	0.703	0.237
Total land holding size (hac.)	0.644	0.338
Radio	0.536	0.199
Mobile	0.190	0.188
Television	0.572	0.398
Computer	0.580	0.274
Bio gas/ improved cooking	0.348	0.382
Money spent on improved seeds (Rs.)	0.567	0.552
Money spent on fertilizers (Rs.)	0.674	0.647
Money spent on pesticides (Rs.)	0.315	0.256
Time taken to reach nearby road (min.)	-0.008	-0.104
Time taken to reach agriculture service centre (min.)	-0.095	-0.082
Level of knowledge/ information on CC	0.521	0.476
Irrigation frequency	0.293	0.181
Access to credit	0.559	0.510
Saving	0.831	0.616
Membership in any organizations	0.655	0.406
Training/ extension services received	0.517	0.362
Total household income (Rs.)	0.338	0.216
Sensitivity		
Temperature variability (max. and min.)	-0.926	-0.234
Rainfall variability (coefficient)	-0.087	-0.213
Exposure		
Frequency of floods/ landslides	-0.174	-0.312
Drought length	-0.148	-0.389

Extraction method: Principal component analysis.

Eight components extracted

Table 2: Vulnerability Indices Across the Study Area

District	Vulnerability index
Chitwan	8.289
Parbat	5.724

The calculation of vulnerability indices showed that both Chitwan and Parbat districts had positive values implying that they were not severely vulnerable, which means, they were less vulnerable. Chitwan and Parbat in the study sites possessed the indices of 8.3 and 5.7, respectively (Table 2). Higher the net value or indices, lesser the vulnerability and vice versa (Madu, 2012). Thus, it could be concluded that Parbat (mid-hills) was more vulnerable to climate change by its least index in comparison to Chitwan (Terai). The result is in line with the findings of Dhakal (2013) who concluded that, warm temperate region (upper Myagdi) by its least indices (3.29) was most vulnerable while the tropical region (Chitwan) with highest indices (8.11), indicates less vulnerable to climate change.

Adaptation Against Climate Change at the Farm Level

About 61 percent farmers in the study area were seen to adopt the adaptation strategies at varying rate, while others do not adopt any adaptation strategies to cope up with the adverse effects of climate change in agricultural

production. Within this, adoption rate was found higher in Chitwan (73.33 percent) in comparison to Parbat (48.33 percent). Different adaptation strategies practiced by the farmers in the study area are change in crop varieties (80 percent), increasing irrigation/water management (69.29 percent), application of organic manures and biofertilizers (66.70 percent), remittance and outside employment (61.70 percent), change in sowing and harvesting time (45.80 percent), moisture conservation and soil management practices (42.50 percent), change in cropping pattern or crop diversification (35.50 percent), IPM practices (32.35 percent), off-season vegetable cultivation (26.00 percent) and rain water harvesting (5.90 percent).

Determinants of Farmers' Decision on Adopting the Adaptation Strategies

Binary logistic model was used to analyze the determinants of farmers' decision on adopting the adaptation strategies across the study area. Description of variables used in farmer's decision to adopt is presented in Table 3 with summary statistics. The model assumed the farmers' decision on the adoption of adaptation measures to climate change at farm level as a binary dependent variable (Y_i) with '1 for adaptation' and '0 for no adaptation'.

Table 3: Statistical Description of the Variables Used in the Logistic Regression Model

Variables	Description of variable	Expected sign	Variable mean	Standard error
Agehh	Age of HH head in year	-	49.9	1.107
Sexhh	Sex of HH head (if 1- male, 0- otherwise	+/-	0.92	0.024
Caste	Caste of HH (if 1- Brahmin/ Chhetri, 0- otherwise)	+/-	0.64	0.044
Eduhh	Education status of HH head (year of schooling)	+	7.07	0.43
Primary_occu	Primary occupation of HH head (if 1- agriculture, 0- otherwise)	+	0.79	0.037
Econ_active_mem	Number of economically active members in HH	+	4.55	0.198
Landarea	Total cultivated land (hactre)	+	0.51	0.805
Info_climate	Level of knowledge/ information on CC (if 1- clearly, 0- otherwise)	+	0.46	0.045
Credit	HH access to credit (if 1- access, 0- otherwise)	+	0.85	0.033
Saving	Saving of HH (if 1- yes, 0- otherwise)	+	0.74	0.040
Training_ext	Training and extension services received by HH (if 1- yes, 0- otherwise)	+	0.46	0.046
Member_Org	HH involved in any social organization (if 1- yes, 0- otherwise)	+	0.62	0.044
Farming_exp	Farming experience of HH head in years	+	21.7	1.088

Table 4: Analysis of the Determinants Using Logistic Regression Model

Variables	Coefficients	S. E.	P> |z|	dy/dx
Agehh	0.001633	0.00191	0.393	0.0016336
Sexhh	0.026879	0.06472	0.678	0.0268795
Caste	0.087816*	0.04649	0.059	0.0878164
Eduhh	0.035623*	0.00791	0.000	0.0356233
Primary_occu	0.052910	0.05466	0.333	0.0529107
Econ_active_mem	0.00492	0.01272	0.699	0.004928
Landarea	0.00582*	0.00295	0.048	0.0058256
Info_climate	0.03392	0.05501	0.537	0.0339298
Credit	-0.11185	0.07067	0.113	-0.1118573
Saving	0.28203*	0.06359	0.000	0.2820356

Table 4: Contd.,

Training_ext	0.237435*	0.05484	0.000	0.2374356
Member_Org	0.10177*	0.05804	0.080	0.1017733
Farming_exp	0.00042	0.00215	0.845	0.000421

Summary statistics of logistic regression model

Number of observation = 120

F (13, 106) = 45.64

Prob> F = 0.0000

R-squared = 0.8484

Adj R-squared = 0.8298

Root MSE = 0.20709

The analysis revealed Adjusted R^2= 0.8298 which indicates that, about 83 percent of the variation in dependent variable (Y_i) was explained or governed by the independent variables used in the model. Among the thirteen variables, six variables were found statistically significant towards the adoption decision by farmers. Being social background or caste of household (X_{3i}), years of schooling (X_{4i}), total cultivated land area (X_{7i}), saving of household (X_{10i}), training and extension services received (X_{11i}) and member of organization (X_{12i}) shows positive and significant impact on adaptation decision, whereas other variables like age of household head (X_{1i}), sex of household head (X_{2i}), primary occupation (X_{5i}), no. of economically active members (X_{6i}), level of knowledge/ information on climate change (X_{8i}), access to credit (X_{9i}) and farming experience (X_{13i}) have no significant impact on adaptation decision.

The study revealed that social background or caste of the household was positively significant ($P< 0.01$) on adaptation decision. If the farmer is from higher caste i.e. Brahmin/ Chhetri, then the probability of adopting different adaptation strategies increases by 8.7 percent as compared to the other caste.

Education level of the household head was found positively significant ($P< 0.01$) on practicing adaptation strategies to climate change. According to the finding, keeping other factors constant, a unit increase in the years of schooling would result in increase in the probability of adopting adaptation measures by 3.6 percent. Deressa *et al.* (2009) reported that, a unit increase in years of schooling would result into 1 percent increase in the probability of soil conservation and 0.6 percent increase in the change in planting dates, to adopt climate change.

Total cultivated land area (hac.) was found positively significant ($P< 0.05$), on adaptation decision by farmers. The study revealed that, if the landholding size of the farmers increases by 1 hectare, then the probability of adoption increases by 17.40 percent. This may be because the farmers with large landholding size might be financially well off, to adopt new technology and it is possible to adopt farm mechanization and modernization in the large farms, as compared to the smaller farms.

Saving (dummy) had positive and significant ($P< 0.01$) impact on the likelihood of adaptation measures. Keeping other factors constant, if a farmer saved a part of his annual income, this would increase the probability of adopting adaptation strategies by 28.20 percent. Gbetibouo (2009) and Deressa *et al.* (2009) also supported that increase in annual household earnings increases the probability of adaptation.

Training and extension activities (dummy) was statistically significant (P< 0.01) to practice different adaptation strategies. Whether the farmers receive formal or informal training and extension services from different governmental and non-governmental organizations the probability of practicing different adaptation strategies increases by 23.70 percent. Apata *et al.* (2009) in South Western Nigeria and Maddison (2007) in Africa also reported that, provision of extension facilities and training on crop and livestock increases the probability of practicing different adaptation strategies by farmers.

According to the result, whether the farmer was member of various agriculture related organizations, cooperatives or social organizations, the likelihood to adaptation to climate change increases by 10.10 percent. Being the member of organizations it is believed to encourage the adoption of adaptation technology.

Constraints for the Adoption of Adaptation Strategies

About 40 percent of the total sampled households across the study area had not adopted any mitigation strategies to cope up with climate change. They were asked the reasons for not adopting any effective adaptation strategies against climate change. Constraints for the adoption of adaptation strategies were assessed through four points scaling technique viz. strongly agree, agree, disagree and neutral assigning the scores 0.80, 0.70 and 0.60, 0.50 respectively. The major constraints are associated with the lack of knowledge concerning appropriate adaptation measures, low access to water and lack of information about climate change carrying the index values 0.49, 0.45 and 0.42, respectively (Table 26). Similarly, lack of technology, lack of credit or saving/ poverty and, lack of market access and poor transport links in hilly areas were also assessed as major problems on adoption of climate change adaptation strategies across the study area.

Table 5: Problems/ Constraints on the Adoption of Climate Change Adaptation Strategies

Problems on adoption of climate change adaptation strategies	Strongly agree	Agree	Disagree	Neutral	Index value	Rank
Lack of information about Climate change	28	33	9	0	0.42	III
Lack of knowledge concerning appropriate adaptation	37	42	0	1	0.49	I
Lack of credit or saving/ poverty	15	30	19	3	0.38	V
No access to water	33	24	18	1	0.45	II
Lack of market access and poor transport links	7	32	25	3	0.37	VI
Lack of technology	25	38	2	5	0.41	IV
No barrier to adaptation	4	5	25	34	0.32	VII

CONCLUSIONS

The effect of Climate change in Agriculture is adverse as it is highly dependent on weather conditions and climatic patterns. The variability in rainfall and temperature extremes has very severe effect in agriculture especially in countries like Nepal where agriculture is primarily rain-fed and farmers are mainly subsistence and traditional in nature. Poor adaptive capacity of the farmers is hitting seriously to the overall agricultural sector of Nepal, leading to massive cut

off or decline in agricultural productivity. Thus, it is posing great threat to all the dimensions of food security and livelihoods of the farmers. The level of knowledge and information about climate change and its impact was revealed lower in Parbat (mid-hill) in comparison to Chitwan (terai). The coping and adaptive capacity against climate change is less in hilly and remote areas due to the lack of knowledge, awareness, information and technology regarding the climate change, it's impact and appropriate adaptation measures. Therefore, low literacy rate, lack of awareness, lack of appropriate technology dissemination, less development and geographical remoteness has become the hindrances to adapt or mitigate against the climate change in Nepal. Higher caste or social background, high education status of the household head, increase in saving from the household income, large cultivated land holding size, membership in any agricultural or social organizations, and having knowledge/ information about climate change and it's impact were found to increase the likelihood or probability of farmers across the study area to adopt different adaptation strategies against climate change. Therefore, awareness, irrigation facilities, appropriate technology, trainings with membership, education, extension services and credit facility should be provided for complete adoption of the adaptation measures.

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